5 Discourse in a network of mathematics teachers. How teachers collaboratively design inquiry-based statistics lessons

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Abstract

This study focuses on the collaboration in a small network of four mathematics teachers from the same school as a way to realise professional development. We examined transcripts of network meetings, from which we show how decisions were made about a teaching design on statistics for 7th grade pupils and its subsequent implementation. The aim of the teaching design was to introduce students to statistical literacy by letting students independently conduct statistical research. The teachers used an inquiry-based teaching strategy, which was new to them, because they usually follow the textbook to teach statistical concepts. We analyzed the transcripts from network meetings to get insights into the decision-making processes. Teachers engaged in discourse and reached consensus, and the discourse showed teachers' development of knowledge and beliefs, especially on teaching goals, assessment and group work. During the preparation and implementation of the design teachers switched to a statistical literacy perspective. Teachers showed commitment to the teaching design and to the network of colleagues. We found how a collegial network stimulates teachers to cross the line of new pedagogies, even if they do not have a drive to change.

Keywords

Mathematics teaching; professional development; discourse; inquiry-based teaching; statistics

5.1 Introduction

Desired learning outcomes for pupils in statistics education have been formulated as being able to function as an educated member of society in our information age, and having a basic understanding of statistical terms, ideas, and techniques (Rumsey, 2002). In lower secondary education in The Netherlands, core objectives are, for example: *"Pupils can read and interpret statistical representations. They are able to use this information to process and edit tables, graphs or diagrams and use measures of central tendency to characterize the information"* and *"Pupils can use computer programs with which they can process data for statistical means and they can interpret the corresponding output"* (Ministry of Education,

Culture and Science, 1998, p.26). These competences have been denoted as statistical literacy (Ben-Zvi & Garfield, 2004; Schield, 1999). In order to become statistical literate, pupils should be able to understand statistical concepts and reason at the most basic statistical level (Snell, 1999), but they should also become competent in generating and interpreting statistical data. This requires a deep-learning approach from pupils (Mayer, 2008) and a different approach in the classroom than teachers are used to. While teachers normally follow the textbook, they must now guide pupils when they independently conduct statistical research. Consequences for teachers are that they should get used to inquiry-based teaching and new assessment formats. Inquiry-based teaching also requires more responsibility for pupils. Consequently, teachers need to find new ways to steer and evaluate student learning. Such a change in teaching approach requires most teachers to adapt and change their pedagogical approaches. Teachers must plan lesson activities which they expect to contribute to pupils' statistical knowledge. The professional development trajectory in this study tries to support teachers while exploring the pedagogy of inquiry-based teaching.

Where traditional in-service training and staff development have been shown to be inadequate (see Clarke & Hollingsworth, 2002; Fullan & Stiegelbauer, 1991; Guskey, 1986), networks can provide fresh ways of thinking about teacher learning (see, for example: Cordingley, Bell, Evans & Firth, 2005; Jackson & Bruegmann, 2009). However, we often see that the culture of isolation still prevails in many US schools (Crespo, 2006) and also in The Netherlands. The focus in this study therefore is on mathematics teachers collaborating in a small network. The opportunity to learn from and with colleagues stimulates active involvement and articulating what they have learned (Resnick, 1986; Schön, 1991). Although there are several studies which report on mathematics classroom discourse (Khisty & Chval, 2002; Nathan & Knuth, 2003; Schleppenbach, Perry, Miller, Sims, & Fang, 2007), and research reports have been published about the effects of networks in teachers' professional development (Avalos, 2011; Desimone, Porter, Garet, Yoon, & Birman, 2002; Little, 1993; McDonald, & Klein, 2003), not much studies have highlighted the conversations teachers have during network meetings (e.g. Roxå & Mårtensson, 2009). This study tries to narrow down this gap by providing insights into the ways teachers discuss the design and implementation of a new teaching strategy and how beliefs about statistics teaching are affected.

5.2 Theoretical framework

5.2.1 Learning and teaching statistics

Shaughnessy (2010) mentions that he is impressed by how important statistical literacy has become for all of us around the globe. Citizens need to be aware of how certain decisions can be defended or critiqued on the basis of quantitative reasoning using probability and statistics. Statistical literacy is needed, for example, to understand articles in the media, record or interpret results in science, monitor performance of sporting teams, or to quantify social problems (Pierce & Chick, 2011). To become statistical literate, one must have the ability to read and interpret summary statistics in graphs, tables, statements and essays (Schield, 1999). Statistical literacy entails the ability to interpret, critically evaluate and communicate about statistical evaluation and messages (Ben-Zvi & Garfield, 2004). This includes a change in statistics education, which has been laid down in national curricula. In Dutch lower secondary education objectives were formulated as *"pupils learn to recognize mathematics in practical situations"* and *"pupils learn to describe, organize and visualize data"* (SLO, 2007, p. 6). These correspond with the NCTM standards for statistics education for grades 6-8, such as *"Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population"* and *"Discuss and understand the correspondence between data sets and their graphical representations"* (CSSU Math frameworks, 2004, p.17).

It is known that statistics is a difficult subject to learn. Difficulties may be due to several causes: related to the concept that is being learned, to the teaching method used by the teacher, to the student's previous knowledge, or to his ability (Batanero, Godino, Vallecillos, Green & Holmes, 1994). Many conceptual problems have been reported, such as about probability, correlation and per cent, as well as the existence of false intuitions which students bring to the statistics classroom. Sometimes students have developed a distaste for statistics, because they have been exposed to the study of probability and statistics in a highly abstract and formal way. And finally, in the classroom the concepts are presented in isolation from their original applications, which contributed to their global meaning (Batanero et al., 1994). Garfield and Ben-Zvi (2007) describe that inappropriate reasoning about statistical ideas is widespread, similar at all age levels, and quite difficult to change. They also mention that studies focused on developing students' reasoning about data and chance suggest that these ideas are often more complex and difficult for students to learn than has been assumed. Carefully designed sequences of activities that focus on understanding of particular concepts,

using appropriate technological tools, can help students improve reasoning and understanding over substantial periods of time (Ben-Zvi, 2000).

Statistics education includes the teaching of 'recipes' and the teaching of 'data and concepts' (Tolboom, 2012). In traditional statistics teaching the emphasis is laid on 'recipes', algorithms to calculate, for instance, means and standard deviations. Although these algorithms are needed to apply statistics in practice, they give a limited image of the field of statistics 'Data and concepts' offer students the possibility to reason about statistics itself and its application in various situations. In this approach the concept of distribution plays an eminent role. Bakker and Gravemeijer (2002) and Bakker (2004) used computer programs known as minitools to stimulate reasoning skills with regard to data distribution in first-year secondary school pupils, which had little statistical background. These minitools were designed to support the various elements of the concept of distribution as one coherent whole. They found that exploring with the computer programs was a good basis for the activities without a computer and they showed the importance of letting students make their own diagrams and discussing these. The research literature strongly indicates that pupils can learn statistical skills by conducting their own research projects (Garfield & Gal, 1999; Wild & Pfannkuch, 1999; Chance, 2002; Doerr & English, 2003). This means that pupils learn to systematically describe, organize, and visualize data and they learn to critically judge information, representations and conclusions (SLO, 2007). According to Chance (2002) and Rumsey (2002) pupils must learn statistical research skills by means of conducting their own research and gathering their own data. This gives pupils ownership, and allows them to really focus on what information they want to tell and what it means to them. One of the dimensions of conducting statistical research is using the 'investigative cycle' (Wild & Pfannkuch, 1999). The elements of this investigative cycle, Problem, Plan, Data, Analysis and Conclusions, are similar to the research phases that pupils follow when they independently conduct a statistical research project.

The changes in statistics education and the emphasis on statistical literacy, involves a different role of the teacher in the classroom. These roles differ from the traditional roles of teacher as knowledge transmitter and pupil as knowledge receiver. Instead of providing direct instruction to students, teachers help students generate their own content-related questions and guide the investigation that follows (see Keys & Bryan, 2001). McClain and Cobb (2001) developed a teaching method in which pupils actively worked on collecting and interpreting data in meaningful contexts via assignments and using software. Teachers must be sure that pupils present a statistical problem in a relevant context with a legitimate, and relevant,

research question. In addition, the teacher develops appropriate assignments and tests (Rumsey, 2002). Teachers should also pay attention to the use of statistical software, like Excel (e.g. Gould, 2010). Furthermore, Rumsey (2002) recommends teachers to give pupils many opportunities to explain and discuss statistical ideas with each other, and watch closely while they do this (see also Cerrito, 1999). Obviously, as students may be asked to communicate the results of their studies to peers (see also National Research Council, 1996), traditional knowledge tests are not sufficient. Therefore, teachers should develop appropriate assessment procedures (see Garfield, 2003).

Inquiry-based teaching is widely used in science education, because of the similarity between science research projects and statistical research projects. Inquiry-based teaching invites students to explore content by posing, investigating, and answering questions (see National Research Council, 1996), enables pupils to contribute their own ideas and to pursue their own investigations (Jarrett, 1997). Inquiry-bases teaching helps students learn how to investigate, and allows more time for students to assimilate and accommodate information. Teachers should be able to scaffold inquiry instruction for the students to help them develop inquiry abilities (Key & Owens, 2013). To be successful with inquiry-based learning, teachers must have an in-depth knowledge and understanding of the topic being presented. They should have the pedagogical tools to support the students in their thought processes while stimulating their interests in learning more than they already do (Chiapetta & Koballa, 2010).

5.2.2 Teachers' professional development

The OECD *TALIS* study (OECD, 2009, 2014) shows that teacher professional development is generally not meeting the needs of teachers in most countries, for example, in the fields of 'student assessment practices', 'subject' and 'instructional practices'. The main reason for unfulfilled development (according to teachers) is the conflict with their work schedule, but lack of suitable development opportunities is also a significant factor. According to Little (1993), teachers' motives and opportunities for professional development begin with work conditions encountered day by day, like the teaching assignments they need for their pupils and the allocation of discretionary time. Little (1993) describes six principles for professional development, where each principle represents a challenge to some aspect of present practice: (1) Professional development should offer meaningful intellectual, social, and emotional engagement with ideas, with materials, and with colleagues both in and out of teaching; (2) Professional development should take explicit account of the contexts of teaching and the experience of teachers; (3) Professional development should offer support for informed

dissent; (4) Professional development places classroom practice in the larger contexts of school practice and the educational careers of children; (5) Professional development prepares teachers (as well as students and their parents) to employ the techniques and perspectives of inquiry; (6) The governance of professional development ensures bureaucratic restraint and a balance between the interests of individuals and the interests of institutions. This research study is inspired by these six principles: Changes in attitudes, knowledge and (self-efficacy) beliefs may be necessary for teachers in order to benefit from professional development. Being able to express and assess one's own beliefs and knowledge and to indicate the importance of changes therein plays an important role in teacher change (Richardson & Placier, 2001). According to Bandura (1986), efficacy beliefs in particular determine why some people are more ready to change their behaviour than others. Teachers' knowledge and beliefs is partially determined by self-efficacy beliefs, or the degree to which a teacher expects to be able to implement the desired behaviour. Conversely, practical experiences can also increase or decrease efficacy beliefs.

Teaching statistical literacy requires that teachers should not only have statistical knowledge per se but also the availability of other knowledge bases: literacy skills, mathematical knowledge, and context knowledge. To teach statistics, Cerrito (1999) advises teachers (1) to find relevant issues that are of practical importance to the pupils (2) to teach pupils how to find, process, and use technical information based primarily on the tools of statistics, and (3) to provide immediate feedback by giving pupils additional revelations to help them develop critical thinking skills, as pupils have to evaluate results and then reach justifiable conclusions.

According to Pierce and Chick (2011) three factors – the scope of statistics, the recency and place of statistics in the school curriculum, and teachers' backgrounds – must be considered when discussing teachers' beliefs about statistics. Gal, Ginsburg and Schau (1997) examined the role of attitudes and beliefs in statistics education, they found that beliefs important to consider by those involved in statistics education, and therefore also for teachers, may include (1) Beliefs about mathematics (e.g., is it hard/easy), (2) Beliefs about the extent to which statistics is part of mathematics, or requires mathematical skills (e.g., statistics is all computations), (3) Beliefs about what should happen or transpire in a statistics classroom, or expectations as to the culture of a statistics classroom (e.g., a lot of talking about real-world examples), (4) Beliefs about oneself as a learner of statistics or mathematics (e.g., I am good at it), and (5) Beliefs about the usefulness or value of statistics and its importance in one's future life or career (e.g., I will never use it). Beliefs can represent individual ideologies and

commitments (Turner, Christensen & Meyer, 2009) and are accepted as true (Eisenhart, Shrum, Harding & Cuthbert, 1988). People's beliefs have a predictable influence on their attitudes, thus, people construct their attitudes on the basis of their beliefs (Albarracin & Wyer, 2005).

5.2.3 Teacher networks

In this study we have chosen to use a professional development strategy, in which teachers collaborate in a network of colleagues. The network meetings act as a 'sounding board' (see Stiles, Mundry, Loucks-Horsley, Hewson & Love, 2009), in which mathematics teachers jointly develop and evaluate a teaching design.

Knapp (2004) and Day (1999) state that networks are powerful learning environments for teachers. Knapp (2004, p.121) states that: *'(...) The effort of collective sense making often prompts teachers to listen to children differently, examine their own practice more closely and reimagine possibilities for their work'*. According to Lieberman and McLaughlin (1992), successful networks share common features, such as focus, variety, and opportunities for discourse and leadership. In networks teachers have the opportunity to discuss nagging problems concerned with quality, application, stability, overextension, ownership, expanding objectives, leadership, evaluation, and goal-setting.

Little (1990) distinguishes four types of teacher collaboration that form a continuum from independence to interdependence (see also Clement & Vandenberghe, 2000):

1. Storytelling and scanning for ideas refer to rather opportunistic contacts at a relatively great distance from the actual classroom practice. The team members operate almost independently from one another. 'They satisfy the demands of daily classroom life by occasional forays in search of specific ideas, solutions or reassurances' (Little, 1990, p. 513).
2. Aid and assistance bears reference to the asking and giving of help.
3. Sharing relates to the interchange of materials, methods and new ideas.
4. Joint work bears upon team members' meetings that emphasize shared responsibility for teaching, shared ideas about autonomy and support for the professional initiatives of colleagues.

Our type of collaboration is categorized as 'joint work', in accordance with the six principles for professional development (see section 5.2.2). Furthermore, another dimension of teachers' joint work to consider in this study is a common task. In 'joint work' teachers are most dependent on each other (Kwakman, 2003). During network meetings teachers do not just

work together, but more important they are engaged in a process of intellectual negotiation, reaching consensus and collective decision-making (Trimbur, 1989). The work of Cordingley et al. (2005a,b) and Owen (2003) has refined the understanding of the importance of collaboration for professional learning by highlighting the role of joint work and the need for intense and sustained involvement with colleagues. Furthermore, in a context where joint work prevails, both the individual teacher and the school or the working conditions are important (Jackson & Bruegmann, 2009). In addition to the six principles for professional development, literature (Moll, 1992; McLaughlin, 1994; Metz, 1993; Putnam & Borko, 2000; Meirink, Meijer & Verloop, 2007) shows that teacher networks can contribute to teacher change if:

1. Teachers are enabled to exchange experiences and knowledge about their teaching,
2. The network meetings have a clear focus and purpose,
3. There is continuity in the meetings,
4. The meetings are linked to the everyday practice of the teachers involved.

5.2.4 Collaboration and discourse in teacher groups

The study of verbal interactions and discourse provides clues to the way teachers discuss their knowledge and beliefs. Several studies have been published about discourse in collaborative settings (Mercer, 1995; Little, 2002; Crespo, 2006). In this study we will use the terminology of dialogic, authoritative and procedural discourse, which has been used to characterize the discourse between teacher and pupils (Scott, Mortimer & Aguiar, 2006; Setati, 2005). In authoritative discourse the teacher's purpose is to focus the students' full attention on just one meaning. In dialogic discourse the teacher recognizes and attempts to take into account a range of students' and others' ideas (Scott et al., 2006). We will also use the term 'procedural discourse' when the teacher focuses on the procedural steps taken to solve a problem (Setati, 2005). Although Scott et al. (2006) and Setati (2006) describe classroom discourse between students and teachers, it can equally well be used for conversations in other settings as in collaborative teacher networks.

Much of the talk between teachers when designing a teaching strategy negotiates the relationship between a collective obligation (a 'decision', see section 5.3.4) and individual preference. It is interesting to register whether the teachers have agreed (or could agree) to be bound by a common set of guidelines or whether individual teacher discretion, premised on 'valid pedagogical reasons' will prevail (see Little, 2002). In collegial consultation progress emerges from the eventual joint agreement reached (Mercer, 1995). We expect teachers to

learn from collectively making decisions, based on individual arguments. We will try to describe the effects of verbal interaction in the network of mathematics teachers by counting teachers' participation in discussions (see Crespo, 2006, p.36), by identification of decisions made about the design and by marking consensus statements in network meetings.

In collaborative work teachers may take different positions. Clement & Vandenberghe (2000) distinguish three types of professionals: progressive professionals, reactionary professionals and conservative professionals. Teachers who can be characterized as progressive professionals have control over their work. Progressive professionals have no difficulty to account for their work. They do that spontaneously for their work in the classroom as well as for their functioning at school level, within the team. For their work with pupils, progressive professionals account for what they do referring to the well-being of the children, as well as to their achievements. The functioning in the team does not pose any problems. Progressive professionals invest a lot in the team. They do so for professional reasons (and not primarily for sake of friendship, for instance): they want their functioning at the school level to contribute to their professional development. Reactionary professionals have no real control over their work and they do not feel good at what they do. They restrict themselves to their classroom practice and they show no flexibility. Often they are isolated team members. They work on their own and do not keep up with innovations. Even stronger, they feel no need for flexibility. Somewhere in between these two types are the conservative professionals. These teachers feel good, they have control over their work. This feeling is so strong they do not feel the need to change. Conservative professionals do not reject flexibility, but it does not take a very dominant place in the way they shape their professionalism.

5.2.5 Aims and scope of this study

This study focuses on how teachers collaboratively develop and implement an inquiry-based teaching design, and how this affects their knowledge and beliefs on statistics teaching. We intend to show how teachers collaborate and discuss during network meetings.

Considering the recommendations from literature, we make a number of choices regarding our professional development program. Firstly, mathematics teachers collaboratively work on a task where they develop a statistical teaching design, in our case for 7th grade students (12-13 years old), based on the principles of 'joint work' (see 2.3). Teachers plan the lessons, they set objectives and they design instruction and assessment (Cousins, Ross & Maynes, 1994; Pierce & Chick, 2011)**.** Secondly, the student activities designed by the teachers for

their pupils were based on literature on statistics (Shaughnessy, 2007; Batanero et al., 1994, Bakker & Gravemeijer, 2004).

During the network meetings, the teachers discussed the design and method of implementation. This study intends to describe the processes occurring during the meetings and the participation of the teachers to the discourse by examining the conversations on a micro level. We were especially interested in identifying teachers' knowledge and beliefs and how these contributed to the decision-taking process and consensus reaching by the group. Further, we were interested how the group process led to changes in teachers' knowledge and beliefs. We expect that gaining insight in group processes will give us indications in setting up a professional development trajectory that will contribute to teachers' professional activity.

Summarizing, we will answer the following research questions:

1. *How does the composition of the network influence the development process of the teachers?*
2. *What knowledge and beliefs concerning inquiry-based statistics teaching did mathematics teachers develop during network meetings?*
3. *How did the mathematics teachers reach consensus during the network meetings?*

5.3 Method

5.3.1 Participants

This study comprises four mathematics teachers from the same school in a network led by a facilitator. The school is a large comprehensive school in a small town in the north of the Netherlands. The four teachers voluntarily signed up for participation in this study during a meeting attended by all mathematics teachers working at the school. Table 5.1 contains information about the participating teachers. Fictitious names have been used for the teachers for reasons of privacy.

A questionnaire was used to collect information about teachers' knowledge of statistics as well as experiences with statistics teaching, inquiry-based teaching and collaboration with colleagues. This is important information, because past experiences may affect teachers' knowledge and beliefs (Meijer, 1999; Bandura, 1986). It appeared that Christine and David had no experience at all in supervising statistical research. Annet and Bart supervised one

project in the 9th grade. In general, we can say that the teachers did not have much experience with inquiry-based teaching. Furthermore, experiences in collaborative working with colleagues were also limited. For example, teachers mentioned 'Tailoring levels and skills of pupils, tests and study guides' (Annet), 'Coordinating tests and the curriculum' (Bart), 'Departmental meetings and exchanging information about groups, approach, etc. on an irregular basis' and 'Meetings about parallel groups and cautious attempts at innovation' (David). Referring to Little (1990) teachers had some experiences with 'storytelling and scanning for ideas' with 'aid and assistance' and with 'sharing', but not with 'joint work'.
Teachers' knowledge of statistics varied and usually could be traced back to their own teacher training, as Christine articulated: 'During teacher training course, a long time ago' or Annet: 'During teacher training course – subject knowledge has largely been forgotten'.

Table 5.1: General information about the participants in the study during the school year 2006-2007

Name of teacher	Sex	Age	Number of years of experience in education	Number of years of experience teaching in the first stage of secondary school	Attended network meetings
Annet	Female	48	10	3	1-7 (all)
Bart	Male	47	18	18	1-7 (all)
Christine	Female	47	23	23	1-4 & 7
David	Male	56	6	6	1 & 4-7

5.3.2 Network meetings

During network meetings the teachers jointly developed a teaching design for 7th grade pupils, the first year of Dutch secondary education. During the first six network meetings the four teachers collaboratively determined the content, structure and implementation of the teaching design. The seventh meeting was an evaluation meeting and took place after the teaching design had been implemented in November 2006 (see table 5.2). Each network meeting lasted 50 to 90 minutes, depending on how much time the teachers had. During the first network meeting, the teachers agreed on a minimum of six network meetings, of which they thought were necessary to develop and evaluate the teaching design.
In order to achieve the aims of the network meetings, we set up a series of events. Table 5.2 contains an overview of events during the network meetings. The network meetings aimed at

setting goals, personal goals as well as teaching goals, sharing experiences, developing and evaluating the teaching design.

Table 5.2: Overview of events during the network meetings

Network meeting	**Events**
Number 1-6 First network meeting on 4 April 2006. Sixth meeting on 31 October 2006	1. Development of a teaching design, including objectives, design of teaching materials, teaching strategies, organisation of group work, and knowledge test. 2. Introduction to inquiry-based teaching and examples of statistics teaching (e.g. software packages) 3. Renewed acquaintance with statistics by, for example, reading literature. 4. Organisation of the implementation of the teaching design. 5. Creating commitment to the subject and to the group by making agreements on carrying out plans and tasks.
Number 7 Evaluative network meeting on 18 December 2006	1. Reflection on the joint development of teaching and on the teaching design and its implementation. 2. Indicating points for improvement in the teaching design.

The facilitator gives structure to the network meetings and monitors the development and evaluation process of the statistical teaching design by means of:

1. Organizational responsibility, for example ensuring the continuity of the network meetings.
2. Substantive responsibility, for example, providing information and relevant literature in the field of statistics and statistical education.
3. Moderating and streamlining of the group process and the developmental process, for example, by clarifying goals and topics, and summarizing important issues.

However, the facilitator explicitly did not interfere with content, form and implementation of the teaching design. Teachers had to reach consensus about these parts in order to increase their motivation and dedication to the developed statistical teaching design.

5.3.3 Characteristics of the statistical teaching design

The student activities designed by the teachers for their pupils were based on literature on statistics (Shaughnessy, 2007; Batanero et al., 1994) and included: (1) formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them, (2) select and use appropriate statistical methods to analyze data, especially by choosing a representative of the data, like the mean, mode or median, (3) make frequency tables and choose correct graphical representations to the data, like bar graphs, line graphs and circle diagrams, (4) derive meaning from graphs or diagrams created by others or by themselves, and, at an informal way, (5) refer to the existence of statistical dependence between two, self-chosen and realistic, variables (Ridgway, Nicholson, & McCusker, 2011). Together, these activities form the investigative cycle (Wild & Pfannkuch, 1999)

As a result of the network meetings, the teachers formulated the following characteristics of the statistical teaching design:

A. Preparatory phase

The literature discussed in section 5.2.1 revealed that mastery of statistical concepts (Garfield, 2003), the ability to analyze data using a computer program (McClain & Cobb, 2001) and the ability to follow an investigative cycle in a structured manner (Pfannkuch & Rubick, 2002) are preconditions for independently conducting statistical research.

Before they carry out their own research, they have two introductory lessons. During the first 50-minute lesson, pupils are introduced to a statistical computer program (Excel, VU-Statistiek). In the second 50-minute lesson, pupils are introduced to:

1. Completing an investigative cycle under supervision of the teacher.
2. Working from a given problem. If students think about a problem, they come with questions. Where necessary, the teacher gives the corresponding statistical concepts (measures of central tendency, extremes, outliers, sample, use of samples of different sizes, representative sample, correlation) and graphical representations (bar graphs, line graphs and pie charts or circle diagrams).

B. Pupils conduct their own research, following an investigative cycle

In eight lessons of 50 minutes, pupils follow the entire research process, from thinking up a topic to creating the poster.

The investigative cycle is based on a number of recommendations formulated by Doerr and English (2003), Chance (2002), McClain and Cobb (2001) and others.

1. In groups of four pupils, each pupil proposes two statistical research topics, after which a brainstorming session will result in one topic plus research question. The teacher provides feedback on the choice made.
2. Each group draws up a plan of approach for the implementation of the research. The teacher provides feedback.
3. The pupils present their topic, research questions, methods and research plan to the other groups.
4. Halfway the process, the group reports to the teacher for written feedback on their progress. The teacher provides suggestions for adaptations to the plan of approach and further steps.
5. After each meeting, the group draws up a work report in the form of a logbook, in which problems are identified, plans are compared to the actual implementation, etc.

The teacher gives feedback on this logbook.

6. The data collected by the pupils are processed with a statistical computer program.
7. Conclusions are summarized on a poster and presented.

Adjacent to their own research, the students receive a written knowledge test about statistical concepts and representations. Both the test and the poster are part of the final assessment.

5.3.4 Data source

All network meetings were taped with a voice recorder and subsequently transcribed. Network meetings were transcribed verbatim and imported in MEPA (Erkens, 2002). MEPA (Multiple Episode Protocol Analysis) is a flexible program for the annotation of, coding and transcription of verbal or non-verbal qualitative data.

The transcripts enabled us to examine teachers' actual contribution to the discussion. The transcripts gave an overview of the course of the discussion, moments of persuasion and reaching consensus. The transcripts also indicated whether the network meetings functioned as a stimulating learning environment for the teachers. Transcripts of the seventh and evaluative meeting showed teacher's experiences with the implementation of the design. The teaching design in itself is not discussed in this paper, because our focus is on the design decisions during network meetings.

5.3.5 Data analysis

5.3.5.1 Decisions and preparatory statements

As a first step in our data analysis we marked those statements that indicate decisions. An example of a decision is that teachers agreed that a goal of the teaching design should be that pupils gain an understanding in statistics (network meeting 1). A decision is recognized as a commonly shared resolution (reaching consensus) about the teaching design or the implementation of the teaching design. In many cases decisions were identified quite easily. In some cases, it was more difficult, for instance when a teacher first made a statement, which later turned out to be the decision. Only from the context of the conversation can be established whether consensus was reached.

After having identified the decisions, we identified those verbal statements that related to a particular decision, which we called preparatory statements. Other statements were not considered. Although the focus in this study is on decisions, preparatory statements are particularly important as they indicate teachers' participation and contributions to consensus

in the group. Preparatory statements may contain evidence about to individual knowledge and beliefs, while decisions refer to a joint views.

Table 5.3 shows types of decisions (see also Zwart, Wubbels, Bolhuis, & Bergen, 2008) and preparatory statements. In the transcribed network meetings we found statements that contribute to the realization of decisions, as demonstrated in table 5.3. The types in table 5.3 are authoritative (type 1), dialogic (type 2) or procedural (type 3), according to Scott et al. (2006). We found that preparatory statements are expressions that *contribute* to decisions or expressions that *confirm* decisions.

Table 5.3:Types of decisions and preparatory statements

Types of decisions	**Types of preparatory statements that contribute to the realization of decisions**
1. Confirmative statement For example, statements contain: *Yes; Okay; I agree; I can find myself in; Fine; It is clear; We have to ensure that …* 2. Summarizing statement For example, statements contain: *So we found that*; S*ummarizing, we can say that; So; Thus*	1. Authoritative statement (individual viewpoints, ideas, suggestions and proposals) For example, statements contain: *Important is; Teaching goals are …* 2. Dialogic statement (sharing ideas, checking other's ideas, debating, asking questions) For example, statements contain: *We have a choice of; Refer to experiences with earlier assignments; What about? How? Can you explain? Which choices do we give the pupils? Is it intended that? So, initially you want? I don't agree with you that …* 3. Procedural statement For example, statements contain: *We have to decide that. How do we divide tasks?*

5.3.5.2 Development of themes

After having marked 'decisions', we categorized these into different themes, like 'pupils choose topic', 'planning of teaching', 'teacher role' and 'discussing material'. We used a grounded theory approach (Corbin & Strauss, 2008) to develop and adjust these themes. As

the initial list of themes was quite long, we have merged themes in order to get a broader classification. Eventually, about sixteen themes were agreed between reviewers, for example 'study progress by pupils (monitoring)', 'use of ICT (Excel)' and 'requirements for the poster'. We decided to highlight three themes in this paper, as many decisions were taken about these themes and, furthermore, these themes were distinctive and important and frequently occurred during network meetings. These themes are 'subject matter', 'assessment' and 'group work' (see table 5.4).

When categorizing statements as decisions and preparatory statements, and classifying them into categories we have worked together in a group of raters in order to get a reliable classification. This was an iterative process, in which we ultimately agreed on all classifications.

Table 5.4: Themes, description of themes and examples

Theme	**Description of theme**	**Examples**
Subject matter	Statements about statistics, statistical concepts, learning and teaching statistics, objectives of the teaching design.	1. *It's not always about understanding means, modes and medians and those things. But if we are talking about research skills, then I do think it's necessary. For them to have that. That understanding of statistics.* (Annet, network meeting 1) 2. *The real goal of course is, that they go to work. And research skills* (Annet, network meeting 1)
Assessment	Statements about formative and summative ways to determine students' knowledge and skills.	1. *I think it would look nicer to add the report: 'This is how we made the poster'*. (Annet, network meeting 1) 2. *You (pupils) evaluate the posters of other groups and you devise two questions* (David, network meeting 4) 3. *It (the final knowledge test) must have a knowledge component and an evaluation component?* (David, network meeting 4)
Group work	Statements about organization and supervision of students working in groups.	*Groups of five I find too big. Then you have two who scrimshank* (Bart, network meeting 5)

5.3.5.3 Evaluative statements

Evaluative statements only appeared in the evaluative network meeting, where teachers looked back on the implementation of the teaching design. We identified these evaluative statements and coded these according to the earlier agreed themes.

In this paper, we will discuss only those evaluative statements that refer to the themes subject matter, group work, and assessment, corresponding to the categories we presented in table 5.4.

5.4 Results

5.4.1 Contribution of individual teachers to the decision making and evaluation process

In section 5.4.2 we will present the results per theme, but first we give an overview of teachers' contributions to the decision-making and evaluation process. Table 5.5 presents the number of decisions, preparatory statements and evaluative statements made by each of the teachers.

Table 5.5: Decisions, preparatory statements and evaluative remarks per theme per person in absolute numbers and percentages

Decisions, preparatory statements and evaluative statements	**Annet**	**Bart**	**Christine**	**David**	**Facilitator**	**Total**
Decisions about subject matter	19	7	1	1	4	32(42.1%)
Decisions about group work	6	5	0	0	0	11(14.5%)
Decisions about assessment	16	2	3	10	2	33(43.4%)
Total decisions	41 (53.9%)	14 (18.4%)	4 (5.3%)	11 (14.5%)	6 (7.9%)	76 (100%)
Preparatory statements about subject matter	79	55	38	36	88	296(50%)
Preparatory statements about group work	33	20	12	10	37	112(19%)
Preparatory statements about assessment	50	20	16	31	66	183(31%)
Total preparatory statement	162 (27.4%)	95 (16.1%)	66 (11.2%)	77 (13%)	191 (32.3%)	591 (100%)
Evaluative statements about subject matter	12	20	14	3	18	67(38.5%)
Evaluative statements about group work	25	34	6	13	20	98(56.3%)
Evaluative statements about assessment	4	0	2	0	3	9(5.2%)
Total evaluative statements	41 (23.5%)	54 (31%)	22 (13%)	16 (9%)	41 (23.5%)	174 (100%)

Table 5.5 enables a tentative qualification of the teachers. Table 5.5 shows that all teachers made a substantive number of preparatory statements, but that Annet verbalized by far the most decisions (41). Bart shows the most evaluative statements (54), especially about group work (34). Christine verbalized few decisions (4) and also, in comparison with the rest, few preparatory statements. This is probably due to her absence in the 5th and 6th network meeting (see table 5.1), although her average number of statements per meeting is also low. David verbalized 11 decisions, of which 10 about assessment. This is not surprising, because David volunteered to take responsibility for the test. Together with Christine, David had less decisions and preparatory statements compared to Annet and Bart. David was also absent during two network meetings (see table 5.1).

Noteworthy is the role of the facilitator, with 191 preparatory statements. An explanation is that her decisions (6) are mainly summaries or verbalizations of discussions by teachers after consensus was reached. In that case, none of the teachers explicitly formulated the decision made. The same applies for the number of evaluative statements by the facilitator (41).

Group work is, in summary, the most discussed theme during the evaluative network meeting, with 98 statements. This was not totally unexpected, as the teachers had not much experience with group work. As an illustration, Bart mentioned during the evaluative network meeting: *"Controlling the group and the atmosphere in class. Normally I get to teach actual groups, which ensures a certain atmosphere in class. But I've completely lost that now"*.

5.4.2 Discourse on themes

In this section we present an overview of the results per theme. For each theme, 'subject matter', 'assessment' and 'group work', we describe examples of the decision-making process, examples of evaluations and a summary with the most important findings. In all transcripts below, decisions are marked in italics.

5.4.2.1 Subject matter

Design of subject matter

Below follows a transcript in which we illustrate how decisions were made in the group of teachers. The transcript is from the first network meeting in which teachers discuss the statistical subjects that students need to learn (teaching goals), and accordingly the goals of the teaching design. Christine introduced the theme in network meeting 1 (line 1), where she doubted the pupils' understanding of the statistical concepts mean and median. Bart replied

that to his opinion immediate understanding is not really necessary (*"Do they need to really understand something?"* (line 2) and *"It's only later, when you need it in your follow-up studies, that the understanding suddenly comes"* , (line 4). Bart's opinion was subscribed by the others (David: *"I don't really care about understanding",* line 3. Annet: *"It's not always about understanding means, modes and medians and those things",* line 9). At the same time, teachers emphasized the relevance of students' ability to categorize or plot data (Bart: *"Or you want to investigate something, and then you have to be creative enough to be able to categorize the things you see around you"*, line 11. Annet*: "And also if you want to have a critical attitude towards everything you read that is presented in a statistical way"*, line 12. David*: "How should I interpret a story. How do I map that"*, line 13. Christine: *"To go look for those data. Even before you know what a mode and a median are"*, line 14).

This transcript shows how teachers' beliefs about the teaching of statistical concepts shifted. They were familiar with teaching definitions of mean, mode and median, and let students solve exercises to apply these concepts. Because they collaboratively work on the design of student tasks in which students use statistics as a tool for their investigations, they were pressed to agree on teaching goals and the role of statistical concepts. In students' investigations their role became subservient to aims of statistical investigation.

Transcript 1: Subject matter, network meeting 1

1	Christine	(…) But the mean, the median, they use it, but real understanding is only a small part.
2	Bart	But I think that's important. Do they need to really understand something? (people snigger) No, seriously. I've often thought in the past, 'I don't know what I'm doing, but it's going well, so fine.' At a certain point when you really need it, when you get a bit older, the understanding will come. Is it really necessary to have that understanding at that moment?
3	David	I don't really care about understanding. What I care about is.
4	Bart	I learned logarithms. And I had no idea what I was doing. I was differentiating. I had no idea what I was doing. It's only later, when you need it in your follow-up studies, that the understanding suddenly comes. But do you really need that understanding in third or fourth grade?

5	Facilitator	No, that's not necessary.
6	Bart	Because I wonder about that. Because that is an important question.
7	Annet	That's not necessary at all.
8	Christine	It can be an advantage.
9	*Annet*	*It's not always about understanding means, modes and medians and those things. But if we are talking about research skills, then I do think it's necessary. For them to have that. That understanding of statistics.*
10	Bart	Yes, that's true.
11	David	What I'm trying to say is: You have a problem somewhere. Or you want to investigate something, and then you have to be creative enough to be able to categorize the things you see around you. And then to know that there are tools like measures of central tendency, means and possibly statistical assessment of matters. That might take you a lot further. You need to know that you can do things with them.
12	Annet	And also if you want to have a critical attitude towards everything you read that is presented in a statistical way. Well, you get that in all subject fields. They can apply it there too. Look, of course it's not about them understanding everything; distances and averages.
13	David	I understand that. All the way towards the end, when you look in particular at the A stream, where you get a bit of statistics with hypothesis testing. And the stories that often go along with that, so that you learn right from the start: 'How should I interpret a story. How do I map that.'
14	Christine	Then a good basis would be to make up that story yourself. To go look for those data. Even before you know what a mode and a median are.

In transcript 2 (meeting 1), the discussion about the introduction of statistical concepts continues. Teachers had read a paper (Bakker & Gravemeijer, 2004) and they discussed the contents. The former teacher discussion ended with the conclusion that data analysis comes

before the calculation of measures of central tendency (transcript 1, line 14). In fact, the contents of the article supported the teachers' former decision made, and the facilitator used the article to introduce more accurate wording, like *"Pupils must first have some understanding of distribution before they can assess when a mean or median is a useful measure of central tendency"* (transcript 2, line 5). The facilitator pointed at the difference between regular classroom practice and the facilitators' proposal to teach statistics *("We always teach them the measures of central tendency first and then go on to the distributions"* and *"No, you should present it the other way around."* , transcript 2, line 5). The timing of the facilitator's intervention was important here. The decision in the network was formulated in the former part of the meeting and was now established.

Transcript 2: Subject matter, network meeting 1

1	*Bart*	*Of course it is important what it says here, the dataset as a whole. Instead of as a collection of individual elements. Of course that will also be one of the aims.*
2	Annet	That it's not all individual numbers.
3	Christine	Mm, mm.
4	Bart	Isn't it?
5	Facilitator	Look, he even says it here, he says it in even stronger terms. On page 23 he says: 'Pupils must first have some understanding of distribution'. He even reverses it. '... before they can assess when a mean or median is a useful measure of central tendency.' We always teach them the measures of central tendency first and then go on to the distributions. But he says: 'They must learn to see the centre, spread and skewness of the distribution. And they must learn that the centre can be measured, for example, on the basis of the mean and the median. And that the spread can be measured on the basis of the range, interquartile range, standard deviation, and so on.' So he or she, Bakker and Gravemeijer, what they are saying is: 'No, you should present it the other way around.'
6	Bart	I see their point.

Evaluation of subject matter

Transcript 3 presents an example of the evaluation of the implementation of the teaching design regarding subject matter. The transcript shows that some teachers did not take the step towards new teaching. For example, teachers mentioned that they did not succeed in gradually introducing statistical concepts. Mostly due to a lack of time and perhaps, indirectly, a lack of teacher's energy (see Bart, line 9). Bart mentioned*: "I have the feeling that chapter 14 will definitely have to be repeated"* (line 1) and *"I think they still know very little about mode, median, mean, measures of central tendency"* (line 3). The other teachers agreed with him (see lines 4, 10 and 11).

Transcript 3: Evaluation subject matter, network meeting 7

1	Bart	I have the feeling that chapter 14 will definitely have to be repeated. Well, repeated, I mean it still has to be covered. Well, other than that I thought it was rather....
2	Facilitator	Why do you have that feeling?
3	Bart	Yes, that's what I feel. I think they still know very little about mode, median, mean, measures of central tendency.
4	David	They haven't learned a lot about that.
5	Bart	I don't think they know much about that.
6	Facilitator	So why is that?
7	Bart	Because they don't need it and it never occurs. They really don't need the median in those little research projects.
8	Facilitator	But that was your task, to, um....
9	Bart	But you never get round to it. At least I don't.
10	Annet	No, I never got round to it either.
11	Christine	I never got round to discussing the median either.
12	Bart	Some did discuss the mean.

During the evaluation meeting teachers also mentioned that the introduction lesson, intended to give students an orientation on statistical research, was not suitable to introduce the principle of correlation (Bart: *"Then I think: 'Oh .... there is no statistical correlation at all"*). Besides, the term 'statistics' was unclear for pupils (Facilitator: *"The term 'statistics' was not really clear. Pupils wanted to do research on explosions!"*).

Summary subject matter

During the network meetings, teachers discussed a lot about subject matter. Table 5.5 shows that the number of preparatory statements (296) is the largest for subject matter. Also, the number of decisions for subject matter is large (32). Teachers mostly discussed about objectives of the teaching design, the introduction of statistical concepts and the most important concepts for pupils to learn at this stage, the mean, mode and median. During the implementation of the teaching design, teachers found that it was difficult to introduce statistical concepts, because not all groups came up with problems that could be resolved by using statistical concepts. In class, teachers did not explicitly introduced statistical concepts. According to the teachers, pupils had no idea what statistics was. Teachers did not succeed in guiding students smoothly towards a good research topic. During the evaluative meeting, teachers argued that the introductory lesson was not a good example for pupils, as the lesson did not sufficiently acknowledge pupils with the principle of correlation, although this was explicitly intended (see section 5.2.4). Teachers concurred that, in a next trial, the introductory lesson should be adjusted.

5.4.2.2 Assessment

Design of assessment

Transcript 4 (network meeting 1) shows that teachers were searching for a way to assess pupils' understanding of statistics. They were looking for a way to both evaluate the product (line 1, 2) and the process (line 3, 9). Bart started the discussion by asking whether the construction of a poster is a suitable product to grade pupils' work (line 1). Christine thinks that only a poster is not enough (*"I think we also need a report or something, in which a few questions must be answered"*, line 3). Annet was decisive by indicating that a report should accompany the poster in which pupils explain how they made the poster (*"I think it would look nicer to add the report: 'This is how we made the poster"*, line 9). This opinion was accepted by the group. Christine more or less concluded the discussion by mentioning that *"Can the report be used to explain the poster, for example?"* (line 10). Besides the poster, teachers agreed on a knowledge test to assess students individually. Discourse on this test is not shown below.

This transcript shows that teachers did not always follow the proposals of the facilitator. They had their own opinion and beliefs and they dared to defend them (see line 7-9).

Transcript 4: Assessment, network meeting 1

1	Bart	Do we need to make things in between? Will it be a poster? Do we agree on that? Or don't we?
2	David	A poster is possible.
3	Christine	I think we also need a report or something, in which a few questions must be answered.
4	Bart	Yes, yes, okay.
5	Facilitator	Poster plus a kind of terms list. Or an explanation, in the sense of 'This is how we did it.'
6	Christine	Questions that you ask yourself at the start (of the pupils' research project), they need to be answered.
7	Facilitator	Can't that be done on the poster?
8	Christine	No.
9	*Annet*	*I don't really like that. I think it would look nicer to add the report: 'This is how we made the poster.'*
10	Christine	Can the report be used to explain the poster, for example?
11	Annet	Like: we first asked ourselves this question. Then we asked everyone these specific questions. And we collected this and that data.
12	Facilitator	Fine. Yes, sure.

Transcript 5 (network meeting 4) shows that teachers gradually gained new insights about assessment. The discussion in network meeting 1 now continues. This discussion led to criteria for the poster content. Annet suggested that the research questions must be answered on the poster (*"But are the research questions really answered (on the poster)? I think that is what they need to ask themselves"*, line 1). Christine added: *"We could ask 'How is the research question answered?"* (line 2). Furthermore they concluded that measures of central tendency should be mentioned on the poster and should be used adequately (line 17). The facilitator summarized this as: "*Do the graphs that are being used really clarify matters? And are the right measures of central tendency used to answer the question?"* (line 18). Transcript 5 involves research outcomes (poster), but also teaching aims. We see here that the facilitator brought up the role of graphs: *"Do the added graphs really clarify matters?"* (line 6) and *"Would you have found a different graph or measure of central tendency clearer?"* (line 8). With these remarks, the facilitator gave direction to the discussion.

Transcript 5: Assessment, network meeting 4

1	Annet	But are the research questions really answered (on the poster)? I think that is what they need to ask themselves. Or else they should ask for clarification.
2	Christine	We could ask 'How is the research question answered?'
3	Facilitator	Have we even mentioned the term research question in our entire discussion so far?
4	Annet	Yes, right at the start.
5	Christine	At the start. The very start. When we were talking about making choices. You could ask 'How is the research question answered?' And then you can discuss how. And to what extent. Is it clear? Are they able to ask themselves the questions that they still need to ask the pupils to make it clearer or more complete? Or something.
6	Facilitator	Do the added graphs really clarify matters?
7	Annet	Do they really tie in with the topic?
8	Facilitator	Would you have found a different graph or measure of central tendency clearer?
9	Annet	We didn't mention measures of central tendency.
10	Facilitator	Well, they could be working with means, for example. While in the case that was studied a mode would have been clearer. I'm just thinking up an example. They should be able to get that out of it.
11	Annet	Yes, but can we already mention that there? Measure of central tendency, the concept measure of central tendency?
12	Facilitator	I don't know.
13	Annet	I think that should be possible there. That should have been covered by then.
14	Facilitator	I would think so. That's right at the end, isn't it?
15	Annet	That's a good idea, to include the measures of central tendency there. So that they are at least discussed. That's a very good idea.

16	Christine	How did you phrase it?
17	Annet	Has a correct measure of central tendency been used?
18	Facilitator	Do the graphs that are being used really clarify matters? And are the right measures of central tendency used to answer the question?
19	*Annet*	*Because if things have been too busy to discuss measures of central tendency, they will have to be discussed here.*

Evaluation of assessment

The evaluation of the assessment showed that pupils' results of the knowledge test were fine, despite the little explicit attention to statistical concepts (Annet: *"Most children had a 6 or higher. And the highest grade was an 8"*. Christine: *"For me between 7.1 en 9.3"*, and David *"And the average was over a 6.5"*). Statistical concepts were not introduced in advance. At Bart's question: *"You also mentioned the mean, mode and median? Or not?"*, everyone responded negatively. The teachers have kept to the agreement that statistical concepts were used as the situation demands it (just-in-time teaching) and were not explicitly introduced by the teacher.

It is remarkable that the teachers did not relate the good test results to the chosen approach, although Annet noted: *"I think they have learned a lot, but it's all a bit vague what exactly"*.

Summary assessment

During the development phase of the statistical teaching design, teachers regularly discussed assessment. Although the theme 'assessment' seemed as important as the other themes, regarding the number of decisions (33) and preparatory statements (183) in table 5.5, the number of evaluative remarks (8) is remarkably low. The evaluation pointed out that the test results for individual pupils appeared to be rather good. As the transcripts show, teachers found it hard to find criteria how to assess the (creation of the) poster and the statistical concepts to be mentioned on the poster. This is evidenced by Annet's statement (*"I think they have learned a lot, but it's all a bit vague what exactly"*). This lack of criteria of the poster leads teachers to regress to the criteria they used in their regular teaching practice, that is with a traditional, written test that evaluates computing the mean, mode and median and the representation of data with bar graphs, line graphs and circle diagrams.

5.4.2.3 Group work

Design of group work

Transcript 6 is from the second network meeting in which teachers discussed the way pupils should work on the introduction assignment during the first lesson of the series. With her question *"In small groups maybe?"* (line 3), Annet started the discussion about group work. Her question led to the decision that pupils should work in groups from the start of the series of lessons, which is obvious because group work fits inquiry-based teaching. Bart found that, by placing pupils in groups, teachers have less control over the group (line 7). However, after exchanging his opinion with Annet and the facilitator (line 8-10), he formulated: *"Groups of four, and they can be formed during that first lesson"* (line 11).

On the one hand, this transcript shows how teachers in consultation came to an agreement, formulated by Bart (line 11). On the other hand, Bart put his beliefs about the adequacy of group work (*"I would like to be able to steer it a bit more. I think"*, line 7) aside. He went along with the flow of the conversation.

Transcript 6: Group work, network meeting 2

1	Bart	You didn't want to give them short assignments or anything? I'm just thinking, so that such a discussion doesn't turn into a whole hour. That, um....
2	Facilitator	You could start by saying: 'Think about it'. They should first get some time to write down how they would like to approach it (i.e. the introductory assignment).
3	Annet	In small groups maybe?
4	Facilitator	Possibly.
5	Bart	Yes, you could have them think about it in small groups.
6	Facilitator	That would perhaps result in more focused ideas, wouldn't it?
7	Bart	I would like to be able to steer it a bit more. I think.
8	Annet	You could have a plenary discussion first. And then, when the question 'think about how you could do this really quickly (i.e. determine which T-shirt sizes the school should order)', create groups.
9	Facilitator	And then the groups should work together? Or in pairs, sitting next to each other?

10	Annet	Yes, maybe. Groups working together. They don't know too much yet at that point. And they have already decided who they want to work with. So they won't influence that too much.
11	*Bart*	*Groups of four, and they can be formed during that first class.*

The discussion about group work was continued in the same network meeting. Earlier in network meeting 2, the teachers decided that pupils will work in groups. Teachers had different views about how groups should be formed. The issue of group formation was self-selection by pupils or group assignment by teachers. The choice of either option would affect the atmosphere in the classroom. Christine supported the view that pupils make groups themselves. Annet articulated: *"Especially in the beginning of the seventh grade, I prefer them to decide "Well I like to work with this person"*. Bart found this difficult, because: *"But what do you do with people who are left over?"*. Bart raised no more objections in this part of the conversation, although he was skeptical about the yield of group work. Eventually it was decided that, depending on the teacher, pupils make their own groups or teachers create groups.

Evaluation of group work

We mentioned that Bart raised objections about group work. In fact, it appeared that Bart's beliefs about group work did not change, which is shown in transcript 7. First, he still doubted about the learning effects of group work (line 1), but Annet argued: *"Then they'd learn different things"* (line 2). Besides that, he felt that he had lost control (line 5), the atmosphere in the classroom was less (line 13) and it took him a lot of organization effort (line 13). We infer that Bart dominated this evaluation, where others occasionally agreed with him.

Transcript 7: Evaluation group work, network meeting 7

1	Bart	There's eight or nine lessons! When I think about how I would do things differently, i.e. in the standard way, I think you could do a lot more in eight lessons.
2	Annet	Then they'd learn different things.
3	Bart	They'd learn different things. Okay, well, fine. But those things

		are less intangible.
4	Annet	We set ourselves goals, like: 'They must learn how those figures end up in that book.' And I don't think they learn that by just working with the textbook.
5	Bart	I don't know. We'll have to look into that. Shall I just continue with my points! I've lost track a bit more. I found things rather chaotic in class and in the school. They barge into the classrooms every now and then to.... And they bother the administration department, and so on and so on. Controlling the group and the atmosphere.
6	Facilitator	Wait, lost track. I take it you are speaking for yourself now?
7	Bart	Yes, I'm speaking for myself.
8	David	I agree with him. And with the first point too, by the way.
9	Facilitator	Does that have anything to do with the working method we've used?
10	Bart	Yes, that too.
11	David	Yes, that too.
12	Facilitator	Of course it's also due to the circumstances. That there were no computers. Those are all unexpected things.
13	Bart	I'll come back to that later. Let me continue. Controlling the group and the atmosphere in class. Normally I get to teach actual groups, which ensures a certain atmosphere in class. But I've completely lost that now. And then the circumstances, the classroom; it was not very convenient for us to have to go from one classroom to another carrying all our stuff around. First you have to spend five minutes putting the tables into groups. Then they come in. And five minutes before the end you have to hurry to. I ended up letting the pupils go five minutes before the end. And then having to put all the tables back, and so on and so on. Clearing up the poster, rearranging this and rearranging that. Influence of microphone/film I've jotted down here, that's an issue too. You do act differently than you would normally do. And so do the pupils probably, though not completely.

Transcript 8 from the evaluation meeting illustrates Bart's beliefs about group work. He remarked (line 1) that some groups had done very nice things, however, his concerns about the benefits of group work remained. The way he participated in this project was: *"Oh well, let's give it another try"* (line 3). He therefore could not be convinced about the value of group work by Annet (line 4, 6) and Christine (line 11, 13). He seemingly had too many negative experiences with group work in the past and these were fostered by this project.

Despite of the disappointing experiences, the teachers, except for Bart, showed that they are, in principle, positive about group work. This is shown by what Annet ("*Because it does have added value... Working together*", line 6, line 8) and Christine said: "*I think they should do that in all subjects... Because in society you also have to work together with all kinds of groups of people you wouldn't normally approach... So I think it's useful in maths class as well*" (line 11, line 13, line 15).

Transcript 8: Evaluation group work, network meeting 7

1	Bart	Promote collaboration. That's undoubtedly true. It makes a change, a different working method. And I hope they are more actively involved in the subject matter. And some groups have done really nice things. They've looked up things. And that is certainly a good thing. I feel this form is... But I already knew that. Otherwise I would of course have done it long before.
2	Facilitator	We also knew that this was how you felt.
3	Bart	We've done group work before. The same things come up. And then I think: 'Oh well, let's give it another try'. Of course you run the risk that it becomes a self-fulfilling prophecy. That risk is fairly big.
4	Annet	I think it's good to deal with a certain topic this way once a year.
5	Bart	I don't know.
6	Annet	Because it does have added value.
7	Bart	I don't know.
8	Annet	Working together.
9	Bart	Do they have to do that in maths class?
10	Annet	Yes, I think so.
11	Christine	I think they should do that in all subjects.

12	Bart	Why?
13	Christine	Because in society you also have to work together with all kinds of groups of people you wouldn't normally approach.
14	Annet	Whatever job you end up in.
15	Christine	So I think it's useful in maths class as well.
16	Bart	Then I would be more in favour of a separate subject. A special course in 'collaboration' or something. Ha, ha.

Summary group work

Although the number of decisions (11) and preparatory statements (112) is rather small compared to the other themes, the theme 'Group work' is the most evaluated theme (98 remarks, see table 5.5). Teachers discussed the value of group work and how to stimulate pupils during group work. The results of the group work were disappointing to the teachers and especially to Bart. Generally, pupils found it difficult to cooperate and teachers had the feeling of losing control in the classroom. However, except for Bart, the teachers still had a positive stance towards group work. It is our interpretation that teachers see the benefits of group work but that they lack skills and, some of them, confidence to organize it in a proper way.

5.5 Conclusions and Discussion

In this study we followed a group of teachers during the process of designing and evaluating a teaching design on statistics in a detailed way. This gave us useful information on the knowledge and beliefs of the four individual teachers and also on the ways teachers reached agreement on three topics we selected ('subject matter', assessment', 'group work'), which were prominently present during the network meetings. By comparing teachers' statements during the design phase (the first six network meetings) with the evaluation phase (during the seventh meeting) we got insights into the change of teachers' knowledge and beliefs.

In answering the first research question *'how does the composition of the network influence the development process of the teachers'*, we concluded from the transcripts that teachers have their own ways to participate in discussions. Annet and Christine acted as progressive professionals, Bart and David as conservative professionals (Clement & Vandenberghe, 2000). Annet and Christine were innovative and acted as triggers. They had the drive to change their teaching practice regarding the statistical content and they made constructive contributions during the network meetings. Bart and David had reservations in changing their

teaching practices. Especially Bart proposed topics for discussion and asked a lot of questions that indicated his uncertainty. It is essential that the coaching strategy should ensure that, within the school, conservative professionals should not become reactionary professionals.

During the evaluative network meeting, teachers expressed that they were satisfied with the way they worked together. David mentioned: *"I think we have been working very constructively. The theoretical structure of the design was very plausible"*. Annet added: *"I also had a good feeling every time after the meetings. Like wow, what have we done a lot!"*. These expressions show that working together was valuable for the teachers. The transcripts in the results section demonstrate that teachers were free to express their concerns and beliefs, which is only possible in a safe environment. This ensured commitment to the teaching design and to the network of colleagues. Important in the process was the interplay between the different types of professionals, which indicates that both types are needed to come to a good decision. Conservative professionals, like Bart and David, were willing to contribute to the network meetings, even if they did not have a drive to change. They followed the progressive professionals, like Annet and Christine, who gave them confidence and a push to cross the line. When they have seen how the design works in their classroom, resulting in positive pupil test results and pupil motivation, the drive naturally developed.

For answering the second research question *'what knowledge and beliefs concerning inquiry-based statistics teaching did mathematics teachers develop during network meetings'*, we selected three topics and showed how teachers' knowledge and beliefs developed within that topics, which are 'subject matter', 'assessment' and 'group work'. Regarding 'subject matter', teachers concluded that pupils do not need to understand all statistical concepts when they start a project. However, they need to categorize and plot data in order to realize later on that the distribution of data may take different shapes. This is a remarkable shift in thinking, because teachers did not consider inquiry as an application of statistical concepts any more, but, instead, they valued the research project as a way to develop students' statistical knowledge. We consider this as an important change in teachers' beliefs. Regarding group work and assessment development of teachers' knowledge and beliefs is less visible. Teachers realized that pupils learned a lot, like skills, but it is difficult for them to identify exactly what pupils have learned. In general, teachers were unwilling to relinquish their autonomy in the classroom, which is inevitable for group work and also for inquiry-based teaching. This had to do with former (negative) teacher experiences and their (efficacy-) beliefs. Regarding assessment, teachers fell back on the traditional test (see 'evaluation of assessment'), despite their original plans to use a more innovative assessment with a poster

created by the pupils. Subsequently, we can conclude that some parts of teachers' beliefs are more easily to change than other parts, depending on how deeply rooted these beliefs are and which earlier positive or negative experiences teachers had. With respect to the teaching goals of the design, teachers were more willing to re-examine their knowledge and beliefs than with respect to group work and assessment. In some way, teachers were afraid to lose control, which is required in student-centered teaching. Especially, conservative professionals have difficulty letting go of authority (Scott et al., 2006).

Teachers did not take a clear position regarding the importance of statistics in the school curriculum, (see also Pierce & Chick, 2011). It seemed that teachers are more focused on guiding student research than on developing statistical concepts. For example, during one of the network meetings Bart mentioned that he usually went quickly through the chapter of descriptive statistics in the 7th grade and that pupils usually got high grades on the written test about this chapter. It seems that he did not pay explicit attention to the value of statistics in the curriculum.

In answering the third research question *'how did the mathematics teachers reach consensus during the network meetings'*, we draw the conclusion that the development of a teaching design stimulated the teachers to come to consensus. Individual knowledge and beliefs merged into joint views, which is needed for reaching consensus. It is clear that consensus was reached in the investigated themes and that, after the implementation of the teaching design, plans were adjusted. Sometimes, however, beliefs were stronger than the knowledge gained, which can make it hard to reach consensus. This was due to the fact that earlier concerns of teachers continued to exist. During the meetings, some teachers were very enthusiastic (Annet, Christine), others were more reserved (Bart, David). A distinction can be made between 'involvement in' and 'contribution to' decisions. Both conservative and progressive professionals can be highly involved, but the type of contribution is different. For example, the involvement of both Annet and Bart is relatively large in the decision-making process and especially in the number of preparatory statements. Although Bart was a conservative professional and Annet a progressive professional, they both strongly contributed to the decision-making process. Differences arose in the way contributions were made. Bart tended to make procedural remarks and Annet authoritative and dialogic remarks putting forward ideas, suggestions and proposals. This can be explained by Bart's feeling that the implication of the teaching design caused that he had lost control over his work. Bart remained uncertain about the implementation of the desired behaviour, arising from his concerns. Although he was supported by his colleagues, his uncertainty became apparent at

the evaluative network meeting. He enumerated a list of concerns, particularly according to the theme he was most uncertain about: group work.

From this study we can give some recommendations about the organization of a teacher network. The first one is that teachers' development is promoted in an environment in which teachers feel free to discuss their ideas and do not have reservations to put forward suggestions. In our network we had a mix of progressive and conservative professionals and we saw how the conservative teachers were willing to follow their progressive colleagues and to cross the line of new pedagogies. Positive collegial relations ensure that teachers feel committed to the network. According to 'joint work', teachers should share responsibility for teaching, they should share ideas about autonomy and the professional initiatives of colleagues should be supported. Due to collegiality teachers were willing to re-examine their beliefs and experiment with novel teaching methods they otherwise would not consider (see also Jackson & Bruegmann, 2009).

A second recommendation is about the role of the facilitator. The six principles for professional development, mentioned in section 5.2.3 (Little, 1993), gave the facilitator guidelines for structuring and monitoring the network meetings. The coaching strategy included the following procedural tasks for the facilitator: give support to teachers, summarize decisions, establish appointments, structure and monitor network meetings. In our strategy, this type of coaching worked out well. It is recommended for the facilitator to keep at a distance when it comes to drawing up form and content of the teaching design. However, this study suggests that, at some instances, the facilitator could be more directive. For example, the facilitator could have proposed strategies for group work that may remove the objections raised by some teachers. A more directive facilitator could give conservative professionals more self-confidence by giving them examples to show that group work can succeed, and that eventually their experience with group work turns out to be more successful.

A third recommendation is about the school environment. The institutional context should be stimulating and not prohibitive, as the professional development of teachers is inextricably linked to their working environment. School principals should pay attention to the fit between the organization's needs and demands and the abilities of individual teachers (Bogler & Nir, 2014). Kwakman (2003) mentions that teachers need social as well as cultural support with regard to their professional learning activity. She refers to the total amount of helpful colleagues and managers that is available within the work context (collegial and management support), and to the extent to which participation in professional learning is appreciated

(intentional learning support). It is important to listen to teachers in their demand for professional development, as teachers are willing to participate more in training activities (Van Veen, Zwart, Meirink & Verloop, 2010). Teachers should have the opportunity to experiment and, obviously, the school board should support these activities. This means that teachers must have the opportunity to participate in longer-lasting and intensive projects, such as course design or curriculum design or doing research in collaboration with colleagues, and that these activities should be recognized by school administrators. Few teachers participate in these types of professional development, while this is, according to them, most effective (OECD, 2009, 2014). A stimulating learning environment also includes 'more good things to happen'. In schools, this means enhanced student performance, increased capacity of teachers, greater involvement of parents and community members, engagement of students, satisfaction and enthusiasm about going further and greater pride for all in the system (Fullan, 2014).

It is important to note that the teachers decided to continue the network meetings in the school year 2007-2008. The experiences were so good, that a follow-up was possible and desired. The idea was to revise the teaching design with the same group of teachers, as all teachers indicated that they wanted to continue the network meetings in the next year. Another success is that the teaching design was adopted by other mathematics teachers of the school and it was implemented in a school-wide project week for pupils. This shows that the experience of collaboratively working on a teaching design formed the basis of a continued process of innovation of mathematics education.

References

Albarracin, D., & Wyer, R. S. (2005). Belief formation, organization and change: Cognitive and motivational influences. In D. Albarracín, B. T. Johnson, & M. P. Zanna (Eds.), *Handbook of attitudes and attitude change* (pp. 273–322). Hillsdale, NJ : Erlbaum.

Avalos, B. (2011). Teacher professional development in Teaching and Teacher Education over ten years. *Teaching and Teacher Education*, *27*(1), 10-20.

Bakker, A., & Gravemeijer, K. P. E. (2002). Leren redeneren over statistische verdelingen; een ontwikkelingsonderzoek [Learning to reason about statistical distribution; a development study]. *Tijdschrift voor Didactiek der ß-Wetenschappen, 19*(1-2), 21-39.

Bakker, A., & Gravemeijer, K.P.E. (2004). Learning to reason about distribution. In J. B. Garfield & D. Ben-Zvi (Eds.), *The challenge of developing statistical literacy, reasoning and thinking* (pp. 147-168). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Bakker, A. (2004). *Design research in statistics education: On symbolizing and computer tools*. Utrecht: CD-ß Press (PhD thesis).

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, New Jersey: Prentice-Hall.

Batanero, C., Godino, J. D., Vallecillos, A., Green, D. R., & Holmes, P. (1994). Errors and difficulties in understanding elementary statistical concepts. *International Journal of Mathematics Education in Science and Technology, 25*(4), 527-547.

Ben-Zvi, D. (2000). Toward understanding the role of technological tools in statistical learning. *Mathematical Thinking and Learning, 2(*1&2), 127–155.

Ben-Zvi, D., & Garfield, J. (2004). Statistical literacy, reasoning, and thinking: Goals, definitions, and challenges. In J. B. Garfield & D. Ben-Zvi (Eds.), *The challenge of developing statistical literacy, reasoning and thinking* (pp. 3-15). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Bogler, R., & Nir, A. E. (2014). The contribution of perceived fit between job demands and abilities to teachers' commitment and job satisfaction. *Educational Management Administration & Leadership, 42*(4), 1-20

Cerrito P. B. (1999) Teaching Statistical Literacy. *College Teaching, 47*(1), 9-13.

Chance, B. L. (2002). Components of Statistical Thinking and Implications for Instruction and Assessment. *Journal of Statistics Education*, *10*(3), 1-18.

Chiappetta, E. & Koballa, T. (2010). *Science Instruction in the Middle and Secondary Schools*. NY: Allyn & Bacon.

Clarke, D., & Hollingworth, H. (2002). Elaborating a model of teacher professional growth. *Teacher and Teaching Education, 18*, 947-967.

Clement, M., & Vandenberghe, R. (2000). Teachers' professional development: a solitary or collegial (ad)venture? *Teaching and Teacher Education*, *16*, 81-101.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (third edition). Thousand Oaks, CA: Sage.

Cordingley, P., Bell, M., Evans, D., & Firth, A. (2005). The impact of collaborative continuing professional development (CPD) on classroom teaching and learning. Review: How do collaborative and sustained CPD and sustained but not collaborative CPD affect teaching and learning? In *Research Evidence in Education Library.* London: EPPI-Centre.

Cousins, J. B., Ross, J. A., & Maynes, F, J. (1994). The Reported Nature and Consequences of Teachers' Joint Work in Three Exemplary Schools. *The Elementary School Journal, 94*(4), 441-465.

Crespo, S. (2006). Elementary teacher talk in mathematics study groups. *Educational Study in Mathematics, 63*, 29-56.

CSSU Curriculum Frameworks (2004). *CSSU Math Frameworks*. Retrieved 2014-05-01 from http://www.cssu.org/cms/lib5/VT01000775/Centricity/Domain/32/CSSUMathCurricMay04.pdf

Day, C. (1999). *Developing teachers: The challenges of lifelong learning*. London: Falmer Press.

Desimone, L., Porter, A., Garet, M., Yoon, K., & Birman B. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81–112.

Doerr, H. M., & English, L. D. (2003). A modeling perspective on students' mathematical reasoning about data. *Journal for Research in Mathematics Education, 34*(2), 110-136.

Eisenhart, M. A., Shrum, J. L., Harding, J. R., & Cuthbert, A. M. (1988). Teacher Beliefs Definitions, Findings, and Directions. *Educational Policy*, *2*(1), 51-70.

Erkens, G. (2002). *Multiple Episode Protocol Analysis*. Utrecht, The Netherlands: Department of Educational Sciences, University of Utrecht. Retrieved from 2012-04-12: http://edugate.fss.uu.nl/mepa/index.htm.

Fullan, M., & Stiegelbauer, S. (1991). *The new meaning of educational change* (second edition). New York: Teachers College Press.

Fullan, M. (2014). *Leading in a culture of change.Personal action guide and workbook*. Hoboken: John Wiley & Sons.

Gal, I., Ginsburg, L. & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal & J.B. Garfield (Eds.) *The assessment challenge in statistics education* (pp. 37-54). Amsterdam, The Netherlands: International Statistical Institute/IOS Press.

Gal, I. (2002). Adults' Statistical Literacy: Meanings, Components, Responsibilities. *International Statistical Review, 70*(1), 1-51.

Garfield, J.B., & Gal, I. (1999). Teaching and Assessing Statistical Reasoning. In *Developing Mathematical Reasoning*, NCTM, 1999 Yearbook.

Garfield, J. B. (2003). Assessing statistical reasoning. *Statistics Education Research Journal, 2*(1), 22-38.

Garfield, J., & Ben-Zvi, D. (2007). How Students Learn Statistics Revisited: A Current Review of Research on Teaching and Learning Statistics. *International Statistical Review, 75*(3), 372–396.

Gould, R. (2010). Statistics and the Modern Student. *International Statistical Review, 78*(2), 297–315.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher, 15*(5), 5-12.

Jackson, C. K., & Bruegmann, E. (2009). *Teaching students and teaching each other: The importance of peer learning for teachers*. NBER Working Paper Series, No. 15202 National Bureau of Economic Research, Cambridge, MA (2009). Available: http://www.nber.org/papers/w15202.pdf

Jarret, D. (1997). *Inquiry strategies for science and mathematics learning: It's just good teaching*. Washington, DC: Office of Educational Research and Improvement.

Key, S., & Owens, D. (2013). Inquiry teaching: it is easier than you think! *The Journal of Mathematics and Science: Collaborative Explorations, 13*(1), 111 – 145.

Keys, C. W., & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching, 38*(6), 631-645.

Khisty, L. L., & Chval, K. B. (2002). Pedagogic discourse and equity in mathematics: When teachers' talk matters. *Mathematics Education Research Journal, 14*(3) 154-168.

Knapp, M. S. (2004). Professional development as a policy pathway. In R. Floden (Ed.), *Review of Research in Education, 27* (pp. 109-157).Washington, DC: American Educational Research Association.

Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education, 19*(2), 149-170.

Lieberman, A., & McLaughlin, M. W. (1992). Networks for educational change: Powerful and problematic. *Phi Delta Kappan, 73,* 673–677.

Little, J. W. (1990). The persistence of privacy: Autonomy and initiative in teachers' professional relations. *Teachers college record, 91*(4), 509-536.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*(2), 129-151.

Little, J. W. (2002). Locating learning in teachers' communities of practice: opening up problems of analysis in records of everyday work. *Teaching and Teacher Education, 18*, 917-946.

Mayer, R. E. (2008). *Learning and instruction*. Upper Saddle River, NJ: Pearson Merrill Prentice Hall.

McClain, K., & Cobb, P. (2001). Supporting students' ability to reason about data. *Educational Studies in Mathematics. 45*(1-3), 103-129.

McDonald, J., & Klein, E. (2003). Networking for teacher learning: Toward a theory of effective design. *The Teachers College Record, 105*(8), 1606-1621.

McLaughlin, M. (1994). Strategic Sites for Teachers' Professional Development. In P. P. Grimmett & J. Neufeld (Eds.), *Teacher Development and the Struggle for Authenticity. Professional Growth and Restructuring in the Context of Change* (pp. 31–51). New York: Teachers College Press.

Meijer, P. (1999). *Teachers practical knowledge*. PhD thesis, University of Leiden.

Meirink, J. A., Meijer, P. C., & Verloop, N. (2007). A closer look at teachers' individual learning in collaborative settings. *Teachers and Teaching: theory and practice, 13*(2), 145-164.

Mercer, N. (1995). *The guided construction of knowledge.* Clevedon: Multilingual Matters LTD.

Metz, M. H. (1993). Teachers' ultimate dependence on their students. In J. Little & M. McLaughlin (Eds.), *Teachers work* (pp. 104-136). New York: Teachers College Press.

Ministry of Education, Culture and Science (1998). *Kerndoelen basisvorming 1998-2003. Relaties in beeld: over de relaties tussen de algemene doelen en de kerndoelen per vak* [Basic core objectives 1998-2003. Relationships in the picture: on the relations between the general objectives and attainment targets for each subject]. Den Haag, The Netherlands: SDU.

Moll, L. C. (1992). Bilingual classroom studies and community analysis: Some recent trends. *Educational Researcher, 21*(2), 20–24.

Nathan, M. J., & Knuth, E. J. (2003). A study of whole classroom mathematical discourse and teacher change. *Cognition and instruction, 21*(2), 175-207.

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

OECD (2009). *Creating effective teaching and learning environments: First results from TALIS.* Paris: Organization for Economic Co-Operation and Development.

OECD (2014). *TALIS 2013 Results. An international perspective on teaching and learning*. TALIS, OECD Publishing.

Owen, S. (2003). *Teacher learning: the power of collaborative thought.* South Australia: University of South Australia.

Pfannkuch, M., & Rubick, A. (2002). An exploration of students' statistical thinking with given data. *Statistics Education Research Journal, 1*(2), 4-21.

Pierce, R., & Chick, H. (2011). Teachers' Beliefs About Statistics Education. In: C. Batanero, G. Burrill, C. Reading (Eds.), *Teaching statistics in school mathematics – Challenges for teaching and teacher education* (pp. 163–174). Dordrecht, The Netherlands: Springer.

Putnam, R. T., & Borko, H. (2000), What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1), 4-15.

Resnick, L. (1986). *AERA Presidential Speech*. American Educational Research Association Annual Conference.

Richardson, V., & Placier, P. (2001). Teacher change. In V. Richardson (Ed.), *Handbook of research on teaching* (pp. 905-947). Washington, DC: American Educational Research Association.

Ridgway, J., Nicholson, J. and McCusker, S. (2011). Developing Statistical Literacy in Students and Teachers. In C.Batanero, G.Burrill and C. Reading (Eds.), *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education* (pp. 311-322). Dordrecht, The Netherlands: Springer.

Roxå, T., & Mårtensson, K. (2009). Significant conversations and significant networks – exploring the backstage of the teaching arena. *Studies in Higher Education, 34*(5), 547-559.

Rumsey, D. J. (2002). Statistical Literacy as a Goal for Introductory Statistics Courses. *Journal of Statistics Education* , *10*(3). Available at www.amstat.org/publications/jse/v10n3/rumsey2.html

Schield, M. (1999). Statistical literacy: Thinking critically about statistics. *Of Significance, 1*(1), 15-20.

Schleppenbach, M., Perry, M., Miller, K. F., Sims, L., & Fang, G. (2007). The answer is only the beginning: Extended discourse in Chinese and U.S. mathematics classrooms. *Journal of Educational Psychology, 99*(2), 380-96.

Schön, D. (Ed.). (1991). *The reflective turn: Case studies in and on educational practice.* New York: Teachers College Press.

Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education, 90*, 605-631.

Setati, M. (2005). Teaching mathematics in a primary multilingual classroom. *Journal for research in Mathematics Education, 36*(5), 447-466.

Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. In *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 957-1009). Frank K. Lester (Eds.). NCTM, 2007.

Shaughnessy, J. M. (2010). Statistics for all - the flip side of quantitative reasoning. *President's Corner*. Retrieved 2014-08-12, from http://www.nctm.org/about/content.aspx?id=26327.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

SLO (2007). *Concretisering van de kerndoelen Wiskunde. Kerndoelen voor de onderbouw VO* [Realization of the core objectives mathematics. Core objectives for lower secondary education]. Enschede, The Netherlands: SLO.

Snell, L. (1999). *Using Chance media to Promote Statistical Literacy*. Paper presented at the 1999 Joint Statistical Meetings, Dallas, TX.

Stiles, K. E., Mundry, S., Loucks-Horsley, S., Hewson, P. W., & Love, N. (2009). *Designing professional development for teachers of science and mathematics.* California: Corwin Press.

Tolboom, J. L. J. (2012). *The potential of a classroom network to support teacher feedback. A study in statistics education.* PhD thesis, University of Groningen.

Trimbur, J. (1989). Consensus and difference in collaborative learning. *College English*, *51*(6), 602-616.

Turner, J. C., Christensen, A., & Meyer, D. K. (2009). Teachers' beliefs about student learning and motivation. In *International handbook of research on teachers and teaching* (pp. 361-371). Springer US.

Veen, K. Van, Zwart, R., Meirink, J., & Verloop, N. (2010). *Professionele ontwikkeling van leraren: een reviewstudie naar effectieve kenmerken van professionaliseringsinterventies van leraren* [Professional development of teachers: a review study on characteristics of effective professional development interventions of teachers]. ICLON / Expertisecentrum Leren van Docenten.

Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review, 67,* 223-265.

Zwart, R. C., Wubbels, Th., Bolhuis, S., & Bergen, Th. C. M. (2008). Teacher learning through reciprocal peer coaching: An analysis of activity sequences. *Teaching and Teacher Education, 24*(4), 982-1002.